TOLERANCE TO ROTATION WITH CONTINUOUS AND INTERMITTENT HEAD MOVEMENTS

F. A. Solodovnik

Translation of "Perenosimost' Vrashcheniy s Nepreryvnymi i Preryvistymi Dvisheniyami Golovoy," Voyenno-Meditsinskiy Zhurnal, Number 4, April 1974, pages 53-55.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D. C. 20546 JUNE 1974

STANDARD TITLE PAGE

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
NASA TT F-15,753		

4. Title and Subtitle	5. Report Date
TOLERANCE TO ROTATION WITH CONTINUOUS AND INTERMITTENT HEAD MOVEMENTS	JUNE 1974
	6. Performing Organization Code

7. Author(s)	8. Performing Organization Report No.
F. A. Solodovnik	10. Work Unit No.

9. Performing Organization Name and Address	11. Contract or Grant No.
Techtran Corporation P.O. Box 729, Glen Burnie, Md. 21061	NASw-2485
	13. Type of Report and Period Covered
	Technical Translation
12. Sponsoring Agency Name and Address	14. Sponsoring Agency Code
National Aeronautics and Space Administration Washington, D. C. 20546	

15. Supplementary Notes

Translation of "Perenosimost' Vrashcheniy s Nepreryvnymi i Preryvistymi Dvisheniyami Golovoy," Voyenno-Meditsinskiy Zhurnal, Number 4, April 1974, pages 53-55.

16. Abstract

Vestibular tolerance to two-side head movements while rotating in a Barany chair was measured in 12 male subjects not subjected to vestibular conditioning for 6 months prior to the experiment. Continuous and intermittent head movements (at intervals of 5 sec) were tested. Continuous head movement was better tolerated, but an illusion of rocking back and forth in the sajittal plane occurred which was absent during intermittent head movement. Continuous stimulation of specific cerebral cortex areas possibly inhibits development of vestibular-vegetative reactions and thus increases tolerance.

17. Key Words (Selected by Author(s))	18. Distribution Statement
	Unclassified - Unlimited

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	4	

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It was the purpose of our investigations to study the tolerance to the /53* influence of rhythmic head movements performed continuously and intermittently by subjects. The studies were conducted on a UVK-64 [1]; male subjects 25-35 years old who exhibited no disturbances of the vestibular function took part in the experiment. The subjects were rotated at a speed of 180°/sec clockwise for 15 sec, and then at the direction of the person conducting the experiment began to perform rhythmic head movements in the frontal plane, tilting the head first in the direction of one shoulder and then the other through an angle of 30° in 2 sec. Hence the first part of the study was carried out in accordance with the method proposed by S. S. Markaryan and coworkers (1966). When an illusion of rocking in the sagittal plane appeared the subjects reported this, continuing to perform head movements smoothly and rhythmically at the former rate (NKUK).

They were subjected to the effects of the rotating chair again after 4-5 days. The speed of rotation of the chair and the speed and amount of inclination of the head remained the same. Each movement of the head toward one shoulder to the other was performed at the direction of the person conducting the experiment at 5 sec intervals, that is, there was a pause between movements during which the subject rotated at uniform speed (PKUK). Thus the conditions of application of the effect to the vestibular apparatus in the two experiments differed only in the presence of a pause between movements of the head during rotation. Application of the effects continued until pronounced vestibular--vegetative reactions (perspiration, paleness, nausea, and so forth) appeared, at which point the vestibular stability was determined. If the tolerance was found to be good, the application was continued for 15 min. None of the subjects had undergone vestibular conditioning during the previous 6 months.

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*Numbers in the margin indicate foreign pagination.

12 persons participated in the experiments. During the rotation involving continuous movements of the head they experienced illusory sensations of walking in the sajittal plane (S. S. Markaryan and coworkers, 1966), which always coincided with definite phases of movement of the head in the frontal plane. No total illusory sensation of rocking in the sagittal plane was detected in the case of rotation of subjects performing head movements at 5 sec intervals. Each movement was accompanied by a brief illusory sensation of tilting of the head and trunk forward or of tilting backward, depending on the direction of movement of the head. When subsequent movement was begun the illusory sensations deriving from the preceding movement were generally absent.

Comparison of the vestibular-vegetative stability in the case of rotation involving simultaneous continuous and intermittent movements of the head (at 5 sec intervals) showed that there is a distinct difference in tolerance to the /54 application of these effects (see table).

Subjects	NKUK	PKUK
1	15	7
2	15	6
3	8	6
4	15	15
5	15	9
6	15	7
7	9	4
8	5	3
9	9	6
10	12	6
11	15	6
12	8	3
	M±m = 11,75±1,07	M±m = 6,5±0,91

As may be seen from the table, the effect of the Coriolis accelerations was stronger in the case of rotation of subjects involving simultaneous intermittent movements of the head ($P < 0.05$) and was not as well as tolerated as in the case of continuous movements. On rotation of a person involving simultaneous movements of the head inertial displacement of the endolymph in the semicircular canals takes place only in the case of rotational movements. With the head in a tilted position during uniform rotation the otolithic apparatus is stimulated only by the resultant of centripetal acceleration and free-fall acceleration. Inasmuch as the condition of motion sickness in the case of rotation involving simultaneous head movements is caused chiefly by stimulation of the semicircular canals, head movement may be considered to be the active stimulus to the vestibular apparatus under such conditions. But since the speed of movement and the angle of inclination were the same in both experiments, the magnitude of the Coriolis accelerations acting on the receptors of the semicircular canals was the same in each head movement. The effects applied differed

only in the fact that in one case the movements were performed continuously and in the other at 5 sec intervals. The differences in vestibular stability and the nature of the illusory sensations are apparently due to the presence of the pause between applications of the effect of the stimulus to the vestibular apparatus.

More frequent irritation of the semicircular canals occurs in the case of rotation involving simultaneous intermittent head movements. It would seem at first that this should cause more rapid accumulation of irritation accompanied by the appearance of motion sickness. However, this was not confirmed by our experiments. Rotation of a person involving simultaneous head movements in the frontal plane results in stimulation of the otolithic apparatus and the semicircular canals, especially the vertical ones. At the same time, displacement of the endolymph in one direction occurs in both anterior and posterior semicircular canals, a displacement which causes the illusory sensations of tilting of the head backward or forward. The direction of displacement of the endolymph depends on the direction of rotation of the head.

The impulses from the receptors of the vestibular apparatus entering the central nervous system are converted in the cerebral cortex to sensations corresponding to the nature of stimulation of the receptors. Intermittently performed head movements cause alternating drains of pulses chiefly from the receptors of the vertical semicircular canals. The directions of the illusory sensations of body movement alternate in the cortex of the large hemispheres, the movements being repeated as often as the rocking movements in the sagittal plane are combined to form one idea. However, a total illusory sensation is not formed exclusively as a result of mechanical combination in the consciousness of illusory sensations of movement in opposite directions. There apparently takes place in this case a rhythmic alternation of the processes of excitation and inhibition in the corresponding functional zones of the cortex, one which results from the frequent arrival of impulses of different directions from the vestibular receptors. This assumption is supported by the fact that the illusory sensation of rocking does not appear immediately after head movements begin but after a certain period of time required for the formation of this sensation in the central nervous system under the influence of the rhythmic impulses of different directions. /55

In the case of the intermittent head movements the illusory sensations are brief and cease before the next movement is performed. The excitation is extinguished in the nerve centers before a new train of impulses arrives from the receptors of the vestibular apparatus, and thus no uniform total illusory sensation of rocking occurs. Prolonged excitation of certain sections of the cerebral cortex and the occurrence of the total illusory sensation probably inhibit the development of other physiological reactions, including vestibular--vegetative ones.

Received in February 1972.

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Translated for the National Aeronautics and Space Administration under contract No. NASw-2485 by Techtran Corporation, P.O. Box 729, Glen Burnie, Maryland, 21061. Translator: William L. Hutcheson.